From: [redacted]
Sent: Thursday, January 26, 2012 1:58 PM
To: [redacted]
Subject: DuPont Burnside PeGASyS Test
Attach: 2011-12-06 DuPont Burnside PeGASyS Test.pdf

Team-

Here is the final report for the PeGASyS test from December. Overall, the results look good from a conversion standpoint and no indications of leaks in the HIP or CIP exchangers. Recommendations deal mainly with the screening the 1st pass due to differential pressure and optimizing some of the inlet bed temperatures. Let me know if you have any questions.

Regards
[redacted]

DUPONT - BURNSIDE

BURNSIDE, LA

EVALUATIONS OF SULFURIC ACID PLANT

PeGASyS

PORTABLE GAS ANALYZER RESULTS AND RECOMMENDATIONS

Written by: Steve Schwab
Sarah Richardson

DuPont Sustainable Solutions
MECS, Inc.

DECEMBER 2011

DSF0000619

DUPONT

BURNSIDE, LA

***PeGASyS* GAS ANALYSIS REPORT**

DECEMBER 2011

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DSF0000620

OBSERVATIONS, CONCLUSIONS, COMMENTS AND RECOMMENDATIONS:

PLANT 1:

Overall, the DuPont (Burnside, LA) Sulfuric Acid Plant was performing with a conversion level of approximately 99.9 % conversion at 2229 STPD with a nominal 10.3 % SO_2 / 10.84 % O_2 feed gas strength during the ***PeGASyS*** testing period. The catalyst was performing well, except for the high pressure drop across Bed 1. There were no heat exchanger leaks found during the ***PeGASyS*** testing period.

The following conclusions and recommendations are based on the data and observations that are discussed in detail in the subsequent sections of this report.

CONCLUSIONS:

BED 1: The overall conversion after this catalyst pass was measured to be approximately 61 %. The catalyst conversion efficiency is estimated to be about 90 %.

BED 2: The overall conversion after this catalyst pass was measured to be approximately 85 %. The catalyst conversion efficiency is estimated to be about 90 %.

BED 3: The overall conversion after this catalyst pass was measured to be approximately 95 %. The catalyst conversion efficiency is estimated to be about 95 %.

BED 4: The overall conversion after this catalyst pass was measured to be about 99.9 %. It is estimated that the conversion efficiency of the fourth bed was approximately 95 %.

CONVERSION COMMENTS:

BED 1: The bed inlet temperature was below the optimum temperature. Increasing the inlet temperature slightly should improve conversion. The measured conversion through this bed was an average of 6% below the equilibrium-allowed value. The measured temperature rise through the catalyst bed agreed well with the calculated temperature rise. The pressure drop through Bed 1 was high due to a recent leak in Waste Heat Boiler # 1.

BED 2: The bed inlet temperature was within the desired range for optimal conversion. The measured conversion through this bed was an average of 5% below the equilibrium-allowed value. The measured temperature rise through the catalyst bed was slightly higher than the calculated temperature rise.

BED 3: The bed inlet temperature was within the desired range for optimal conversion. The measured temperature rise through the catalyst bed was slightly higher than the calculated temperature rise.

BED 4: The bed inlet temperature was below the desired range for optimal conversion through the bed. The recommended minimum bed inlet temperature for cesium catalyst is 390°C (734°F). The measured temperature rise through the catalyst bed was very high compared with the calculated temperature rise. The measured outlet temperature was higher than the equilibrium-allowed value, indicating that there may be gas maldistribution.

OPERATION VS EQUILIBRIUM:

The following graph shows converter performance for the DuPont Burnside converter. There is room for a small amount of conversion improvement in all of the beds.

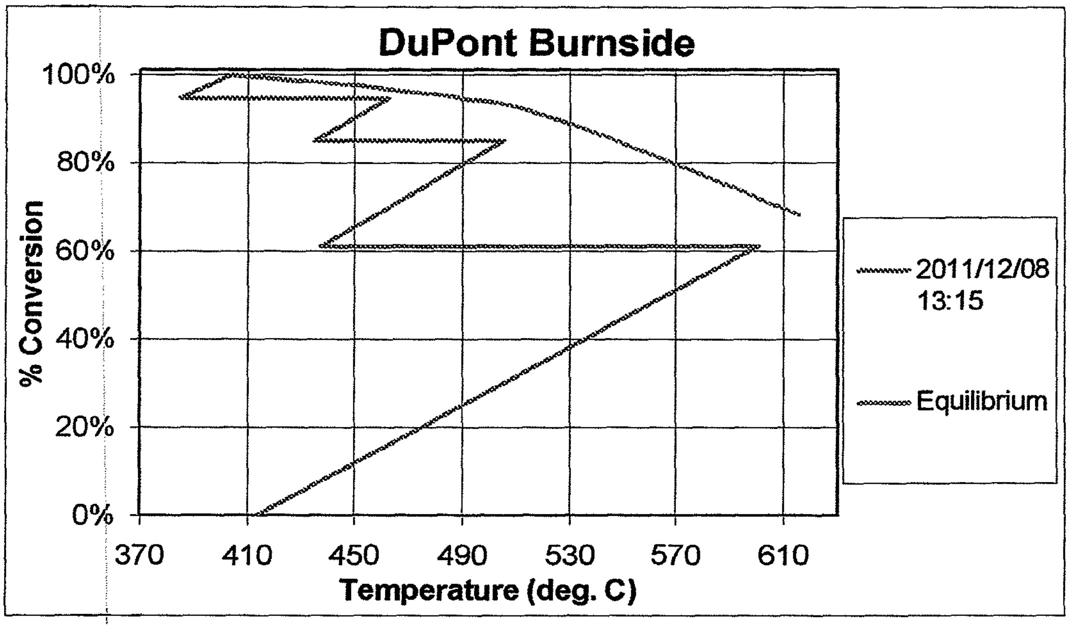


Figure 1: Measured Data VS. Equilibrium Curve

HEAT EXCHANGER COMMENTS:

The Cold IP Heat Exchanger was visually inspected for leaks by qualitatively comparing the level of SO_3 "white smoke" at the low-pressure inlet and outlet sample ports of the respective unit. The Hot IP Heat Exchanger was inspected for leaks based on SO_2 concentration on the low pressure inlet and outlet streams. It was determined that there was no leak in these exchangers. Heat Exchanger data and summaries can be found in Appendix B.

RECOMMENDATIONS:

- Screen Bed 1 and replace losses with fresh MECS XCs-120 and XLP-220 catalyst accordingly to maintain conversion and minimize pressure drop.
- Bed 4 had a measured bed inlet temperature that was out of the desired range. Consider increasing the inlet temperature to approach the optimal value in order to maximize the conversion through the bed.
- Verify that the thermocouples are properly calibrated and positioned at the interface of the catalyst bed and quartz rock. Ensure that all gas taps are clear for pressure drop measurements.
- Inspect and calibrate the stack SO_2 analyzer.
- Determine the inlet temperature that maximizes the temperature rise across each catalyst bed.
- During the next plant shutdown, it is recommended that catalyst samples be taken from each bed and sent to the MECS, Inc. laboratories for activity/hardness evaluations.

PLANT CONDITIONS:

This report summarizes the evaluations of the MECS, Inc. portable gas analyzer (***PeGASyS***) results that were obtained during testing at the DuPont - Burnside (Burnside, LA) sulfuric acid plant on 8 December 2011. The analytical data was collected by Steve Schwab (DuPont/MECS, Inc.) under the direction of Dan Monhollen (DuPont). Any inquiries regarding this report should be directed to Sarah Richardson, Senior Catalyst Product Engineer - MECS, Inc.; St. Louis, MO U.S.A. (Office Phone: 314-275–2974 , Email: sarah.a.richardson@mecsglobal.com).

The ***PeGASyS*** service was contracted primarily in order to investigate the performance of the sulfuric acid plant. Simplified gas flow diagrams for Plant 1, showing the sampling points used in the tests, are presented in Figure 2. The following plant conditions, as provided by DuPont Burnside personnel, served as a basis for the studies:

PLANT	PROD. RATE (STPD)	PASS	CATALYST VOLUME (L)	MEAS. BED Δ P (inWC)	CLEAN BED Δ P (inWC)*
PLANT 1	2229	1	77000	20	3.8
		2	75000	6	4.0
		3	89000	7	6.2
		4	111000	5	4.2

*The estimated clean bed pressure drop is based on the operating conditions (gas concentration, production rate, etc.) of the plant during the ***PeGASyS*** sampling period with new catalyst.

DSF0000625

PORTABLE GAS ANALYSIS SYSTEM *(PeGASyS)* RESULTS:

CONVERTER ANALYSIS:

Two sets of ***PeGASyS*** converter data were collected from DuPont - Burnside during the testing period. The results for each set of data gathered can be found in Appendix -A- of this report. The table at the top of each sheet shows the conversion profile for all of the catalyst beds. Ideally, all of the converter gas samples are taken at the inlets to the various catalyst beds to allow for maximum gas mixing. The catalyst loadings for each bed are listed with the temperatures and are calculated based on the given acid production rate (normalized to 100 % H_2SO_4) and the overall measured conversion.

The ***PeGASyS*** converter data collected was then modeled using the proprietary MECS, Inc. computer simulation program. The results of these simulations are shown in Appendix-C-. The simulations generate an estimate of the conversion effectiveness of each catalyst bed at the given inlet temperatures. The effectiveness takes into account not only the activity of the catalyst, but also the effects of gas distribution, temperature measurement and the mechanical condition of the equipment. For purposes of these simulations, it is presumed that the bed inlet temperatures are accurate; *the results are quantitative only to the level of correspondence between the measured and actual gas temperatures.* The modeling is arranged such that the catalyst activity value is adjusted in order to match the measured conversion level in each pass. The bed outlet temperatures are automatically calculated based on the measured conversions. The results of these simulations were utilized to generate the conclusions regarding the performance of each sulfuric acid plant which were presented earlier in this report.

The feed gas analysis results for Plant 1 could not be directly compared to the SO_2 level calculated from the sulfur burner exit temperature, collected using the standard ***PeGASyS*** method. This is due to an inaccurate thermocouple reading on the sulfur burner exit temperature.

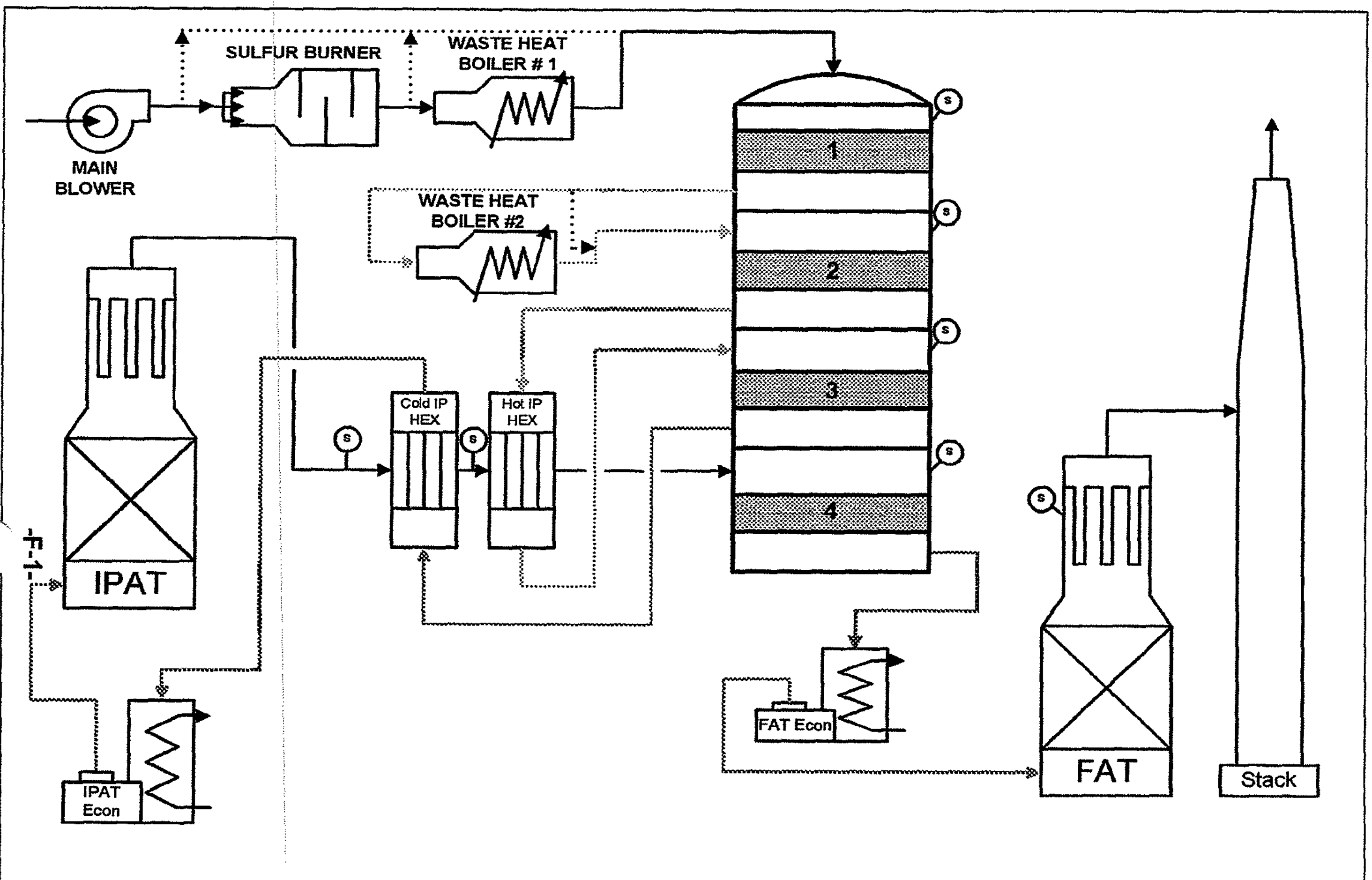
PLANT 1:

DATA SET	SO_2 FROM PLANT CONTROL SCREENS	*PeGASyS* FEED GAS SO_2
8 Dec 11 - 10:15	10.34 %	10.3 %
8 Dec 11 - 13:15	10.38 %	10.3 %

The stack gas analysis results for Plant 1 can be directly compared to the stack gas composition data collected using the standard ***PeGASyS*** method. The following table shows these comparisons:

PLANT 1:

DATA SET	PLANT STACK SO_2 ANALYSIS	*PeGASyS* STACK GAS SO_2	PLANT STACK O_2 ANALYSIS	*PeGASyS* STACK GAS O_2
8 Dec 11 - 10:15	152 ppm	140 ppm	6.6%	6.99%
8 Dec 11 - 13:15	159 ppm	150 ppm	6.54%	6.57%



-F-1-

FIGURE # 2

TITLE	DuPont – Burnside Plant	DRAWN BY	Steve Schwab	"PeGASyS" Converter Gas Analysis by MECS, Inc.	(S) Sampling point used for analysis
DESCRIPTION	4 PASS DOUBLE ABSORPTION SULFUR BURNING PLANT	REVISED	1/24/12	This sketch has been generated to represent basic plant gas stream to aid in sampling, and does not necessarily include all actual elements in the plant	
		FILENAME	DuPont – Burnside.vsd		

APPENDIX –A-

MECS Inc.

CONVERTER PERFORMANCE SUMMARY

CUSTOMER: **DuPont Burnside - Darrow, LA**
DATA SET: 8-Dec-11 at 10:15
PLANT: 1
PLANT TYPE: 4 Pass Sulfur Burning 3X1 Double Absorption

Converter Summary

	Sample Point	SO_2%	O_2%	Conversion %
First pass inlet:	Pass 1 inlet at converter	10.327	10.91	
First pass outlet:	Pass 2 inlet at converter	4.242	9.34	62.923
Second pass outlet:	Pass 3 inlet at converter	1.691	7.46	85.804
Third pass outlet:	Pass 4 inlet at converter	0.594	7.59	95.092
Fourth pass outlet:	FAT below ME	0.014	6.99	99.887

Catalyst Beds

	Temperature °F	°C	Catalyst (Liters)	L/STPD	ΔP (in WC)
1 In	777	414			
1 Out	1119	604	77000	34.5	20.
Rise	342	190	XCs-120 / XLP-220		
2 In	820	438			
2 Out	964	518	75000	33.6	6.
Rise	144	80	LP-120		
3 In	815	435			
3 Out	878	470	89000	39.9	7.
Rise	63	35	LP-110		
4 In	725	385			
4 Out	795	424	111000	49.8	5.
Rise	70	39	SCX-2000		
Total	**619**	**344**	**352000**	**157.8**	

Production

	STPD	MTPD
Acid Production:	2228	2021

	Lbs./Hr.	kg/Hr.
Sulfur Feed:	60777	27568
SO_2 Emissions:	137	62

Lbs. SO_2 / STPD: 1.48
kg SO_2 / MTPD: .74

	SCFM	Nm^3/Hr.
Converter Inlet:	109742	186474
Converter Outlet:	92763	157622
Dilution Air:		

Note: All gas volumes are based on dry, SO_3 -free gas.

Plant Data

Converter Diameter = 38 ft
Gas Flow = 149916 SCFM
Stack Sulfur Dioxide = 152 ppm
Sulfur Burner Air Temperature = 129 C

Acid Production Rate = 2228 STPD
Converter Inlet SO2 = 10.34 %
Stack Oxygen = 6.6 %
Sulfur Burner Temperature = 836 C

MECS Inc.

CONVERTER PERFORMANCE SUMMARY

CUSTOMER: **DuPont Burnside - Darrow, LA**
DATA SET: 8-Dec-11 at 13:15
PLANT: 1
PLANT TYPE: 4 Pass Sulfur Burning 3X1 Double Absorption

Converter Summary

	Sample Point	SO_2%	O_2%	Conversion %
First pass inlet:	Pass 1 inlet at converter	10.292	10.84	
First pass outlet:	Pass 2 inlet at converter	4.422	8.71	61.090
Second pass outlet:	Pass 3 inlet at converter	1.753	7.18	85.210
Third pass outlet:	Pass 4 inlet at converter	0.631	6.87	94.765
Fourth pass outlet:	FAT below ME	0.015	6.57	99.879

Catalyst Beds

	Temperature °F	°C	Catalyst (Liters)	L/STPD	ΔP (in WC)
1 In	777	414			
1 Out	1121	605	77000	34.5	20.
Rise	344	191	XCs-120 / XLP-220		
2 In	820	438			
2 Out	964	518	75000	33.6	6.
Rise	144	80	LP-120		
3 In	815	435			
3 Out	878	470	89000	39.9	7.
Rise	63	35	LP-110		
4 In	725	385			
4 Out	793	423	111000	49.7	5.
Rise	68	38	SCX-2000		
Total	**619**	**344**	**352000**	**157.7**	

Production

	STPD	MTPD
Acid Production:	2229	2022

	Lbs./Hr.	kg/Hr.
Sulfur Feed:	60809	27583
SO_2 Emissions:	147	67

Lbs. SO_2 / STPD:	1.58
kg SO_2 / MTPD:	.79

	SCFM	Nm^3/Hr.
Converter Inlet:	110171	187203
Converter Outlet:	93184	158338
Dilution Air:		

Note: All gas volumes are based on dry, SO_3 -free gas.

Plant Data

Converter Diameter = 38 ft
Acid Production Rate = 2229 STPD
Stack Sulfur Dioxide = 159.3 ppm
Sulfur Burner Air Temperature = 142.4 C
Dilution Air Temperature = 45.7 C

Converter Inlet SO2 = 10.38 %
Stack Oxygen = 6.54 %
Gas Flow = 149012
Sulfur Burner Temperature = 841 C

APPENDIX -B-

MECS, Inc.

HEAT EXCHANGER EVALUATION

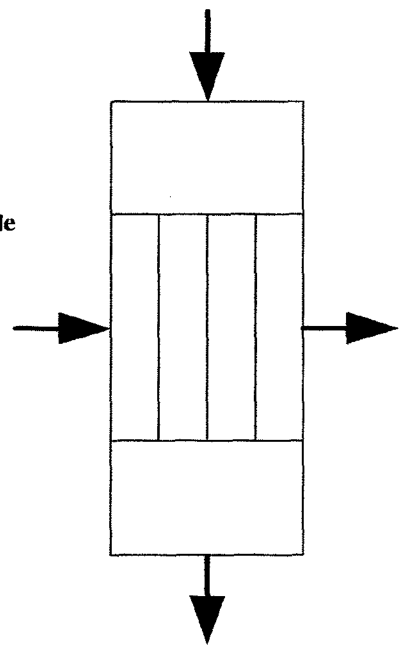
CUSTOMER:	**DuPont Burnside - Darrow, LA**
DATA SET:	8-Dec-11 at 10:15
PLANT:	1
PLANT TYPE:	4 Pass Sulfur Burning 3X1 Double Absorption
HIGH PRESSURE SIDE:	Tube

HEAT EXCHANGER: **HIP**

0.0% OF HIGH PRESSURE SIDE GAS IS LEAKING INTO THE LOW PRESSURE SIDE.

High Pressure Side
In

SO_2 1.691 %
O_2 7.46 %



Low Pressure Side
In

SO_2 0.614 %
O_2 7.08 %

Low Pressure Side
Out

SO_2 0.594 %
O_2 7.59 %

High Pressure Side
Out

SO_2 1.691 %
O_2 7.46 %

Shell side inlet gas was sampled at the Cold IP Hex shell side outlet.
Shell side outlet gas was sampled at the Pass 4 inlet at converter.
Tube side gas was sampled at the Pass 3 inlet at converter

MECS, Inc.

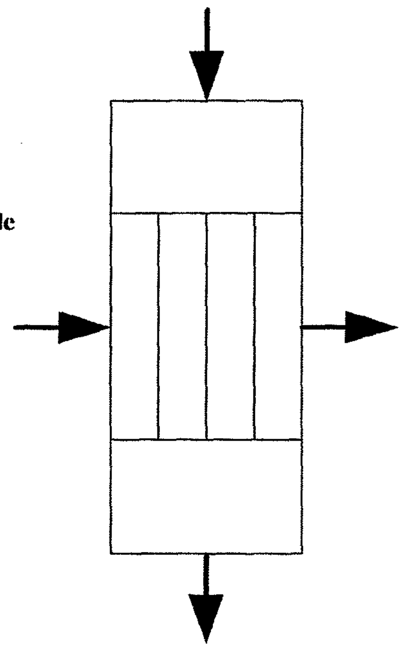
HEAT EXCHANGER EVALUATION

CUSTOMER: **DuPont Burnside - Darrow, LA**
DATA SET: 8-Dec-11 at 13:15
PLANT: 1
PLANT TYPE: 4 Pass Sulfur Burning 3X1 Double Absorption
HIGH PRESSURE SIDE: Tube

HEAT EXCHANGER: **HIP**

0.0% OF HIGH PRESSURE SIDE GAS IS LEAKING INTO THE LOW PRESSURE SIDE.

High Pressure Side
In
SO_2 1.753 %
O_2 7.18 %



Low Pressure Side
In
SO_2 0.639 %
O_2 6.67 %

Low Pressure Side
Out
SO_2 0.631 %
O_2 6.87 %

High Pressure Side
Out
SO_2 1.753 %
O_2 7.18 %

Shell side inlet gas was sampled at the Cold IP Hex shell side outlet.
Shell side outlet gas was sampled at the Pass 4 inlet at converter.
Tube side gas was sampled at the Pass 3 inlet at converter

APPENDIX –C

SO2 OXIDATION REACTOR OPTIMIZATION PROGRAM, VERSION 6 12/20/11

DUPONT BURNSIDE 12/8/11 10:15

SUMMARY OF CONDITIONS:

INLET CONVERSION	0.00	%
EXIT PRESSURE	1.000	ATM
INLET SO2	10.33	%
INLET O2	10.91	%
TOTAL CATALYST	157.80	LITERS/TON, MAXIMIZE TOTAL CONVERSION
INTERPASS ABSORPTION	100.00	% SO3 REMOVED BEFORE PASS 4
DESIGN RATE	2228.0	STPD
DESIGN CONVERSION	99.887	%
REACTOR PASSES	4	

PASS 1:
FIXED INLET TEMPERATURE 414.0 C
FIXED CATALYST LOAD 34.50 LITERS/TON

PASS 2:
FIXED INLET TEMPERATURE 438.0 C
FIXED CATALYST LOAD 33.60 LITERS/TON

PASS 3:
FIXED INLET TEMPERATURE 435.0 C
FIXED CATALYST LOAD 39.90 LITERS/TON

PASS 4:
FIXED INLET TEMPERATURE 385.0 C
FIXED CATALYST LOAD 49.80 LITERS/TON

FINAL RESULT:

PASS	CATALYST LOADING, LI/TON	RELATIVE SULFUR FLOW	GAS COMPOSITION, UNCONVERTED BASIS %SO2	%O2	---- CONVERSION, % ---- IN	OUT	EQUIL
1	34.50	1.0000	10.327	10.910	0.00	62.92	68.34
2	33.60	1.0000	10.327	10.910	62.92	85.80	90.62
3	39.90	1.0000	10.327	10.910	85.80	95.09	96.41
4	49.80	0.0491	0.595	7.037	0.00	97.69	99.16
	157.80		TOTAL			99.887	99.959

PASS	PRESS, ATM	PRECOOL,C	TEMPERATURE, C OR F/C IN, F/C	RISE, C	OUT, F/C	EQUIL, C
1	1.090	0.0	777.2/414.0	186.1	1112.2/600.1	615.7
2	1.060	162.1	820.4/438.0	67.5	941.8/505.5	519.5
3	1.030	70.5	815.0/435.0	27.4	864.3/462.4	466.3
4	1.000	0.0	725.0/385.0	18.2	757.8/403.2	403.5
		232.5	TOTAL	299.2		

SO2 EMISSIONS IN PPM: 138.6
SO2 EMISSIONS IN LB/TON: 1.484

APPENDIX –C

SO2 OXIDATION REACTOR OPTIMIZATION PROGRAM, VERSION 6 12/20/11

DUPONT BURNSIDE 12/8/11 13:15

SUMMARY OF CONDITIONS:

INLET CONVERSION	0.00	%
EXIT PRESSURE	1.000	ATM
INLET SO2	10.29	%
INLET O2	10.84	%
TOTAL CATALYST	157.70	LITERS/TON, MAXIMIZE TOTAL CONVERSION
INTERPASS ABSORPTION	100.00	% SO3 REMOVED BEFORE PASS 4
DESIGN RATE	2229.0	STPD
DESIGN CONVERSION	99.879	%
REACTOR PASSES	4	

PASS 1:

FIXED INLET TEMPERATURE	414.0	C
FIXED CATALYST LOAD	34.50	LITERS/TON

PASS 2:

FIXED INLET TEMPERATURE	438.0	C
FIXED CATALYST LOAD	33.60	LITERS/TON

PASS 3:

FIXED INLET TEMPERATURE	435.0	C
FIXED CATALYST LOAD	39.90	LITERS/TON

PASS 4:

FIXED INLET TEMPERATURE	385.0	C
FIXED CATALYST LOAD	49.70	LITERS/TON

FINAL RESULT:

PASS	CATALYST LOADING, LI/TON	RELATIVE SULFUR FLOW	GAS COMPOSITION, UNCONVERTED BASIS %SO2	%O2	---- CONVERSION, % ---- IN	OUT	EQUIL
1	34.50	1.0000	10.292	10.840	0.00	61.09	68.40
2	33.60	1.0000	10.292	10.840	61.09	85.21	90.05
3	39.90	1.0000	10.292	10.840	85.21	94.77	96.29
4	49.70	0.0523	0.631	6.985	0.00	97.69	99.14
	157.70		TOTAL			99.879	99.955

	PRESS, ATM	---- TEMPERATURE, C OR F/C ---- PRECOOL,C	IN, F/C	RISE, C	OUT, F/C	EQUIL, C
1	1.090	0.0	777.2/414.0	180.3	1101.7/594.3	615.2
2	1.060	156.3	820.4/438.0	70.9	948.0/508.9	522.9
3	1.030	73.9	815.0/435.0	28.1	865.6/463.1	467.6
4	1.000	0.0	725.0/385.0	19.3	759.8/404.3	404.6
		230.1	TOTAL	298.6		

SO2 EMISSIONS IN PPM: 146.8
SO2 EMISSIONS IN LB/TON: 1.578